EXPLORING HYDROELECTRICITY

Teacher Guide

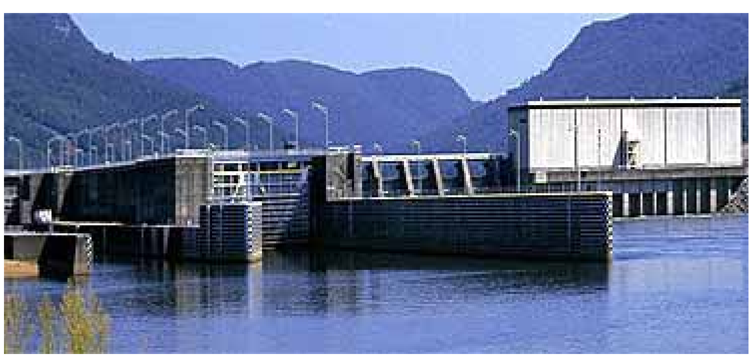
Integrated and inquiry based activities which provide a comprehensive understanding of the scientific, economic, environmental, technological, and societal aspects of hydropower to secondary students.

GRADE LEVEL

Secondary

SUBJECT AREAS

Science
Math
Social Studies
Language Arts
Technology



NEED

2009-2010

Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

Teacher Advisory Board Vision Statement
NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

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EXPLORING HYDROELECTRICITY KIT: $350.00

Materials in Kit
6 64oz. Rectangular Jugs
6 12” x .25” Wooden Dowels
24 Rubber Stoppers
24 1” Disc Magnets
6 Cardboard Tubes
1 Styrofoam Tube
3 Bundles of Wooden Spoons
1 Roll of Double Sided Tape
16 Blank CDs
1 10cm of Plastic Tubing
1 Spool Magnet Wire

Turbine Testing Centers In Kit
3 Water Reservoirs and Caps
3 Funnels
3 Alligator Clips
2 Voltmeters

Science of Electricity Model Materials In Kit
1 Large Round Bottle
1 Small Round Bottle
1 Spool of Magnet Wire
1 12” x .25” Wooden Dowel
4 Rectangle Magnets
5 Rubber Stoppers
1 Foam Tube
10 Wooden Spoons
1 Set of Alligator Clips
1 Multimeter

Materials Not in Kit
3 Water Collection Buckets
6 Permanent Markers
6 Pairs of Sharp Scissors
6 10-penny nails
3 Meter Sticks
3 Towels
12 CDs
1 Pushpin
Water Supply

***EXPLORING HYDROELECTRICITY* was developed by the NEED Project with funding and technical support from the National Hydropower Association and the Hydro Research Foundation.**

APPLICABLE NATIONAL SCIENCE EDUCATION CONTENT STANDARDS

(Bolded standards are emphasized in the unit.)

SECONDARY (GRADES 9-12) CONTENT STANDARD–A: SCIENCE AS INQUIRY

1. Abilities Necessary to do Scientific Inquiry

a. Identify questions and concepts that guide scientific investigation.

b. Design and conduct scientific investigations.

c. Use technology and mathematics to improve investigations and communications.

d. Formulate and revise scientific explanations and models using logic and evidence.

e. Recognize and analyze alternative explanations and models.

f. Communicate and defend a scientific argument.

SECONDARY–B: PHYSICAL SCIENCE

1. Structure of Atoms

a. Matter is made of minute particles called atoms, which are composed of even smaller components. These components have measurable properties, such as mass and electrical charge.

b. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.

c. The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called isotopes of the element.

2. Structure and Properties of Matter

a. Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. These outer electrons govern the chemical properties of the element.

b. An element is composed of a single type of atom.

c. A compound is formed when two or more kinds of atoms bind together chemically.

4. Motions and Forces

c. The electrical force is a universal force that exists between two charged objects.

6. Interactions of Energy and Matter

a. Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

c. Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and, thus, can absorb and emit light only at wavelengths corresponding to these amounts.

SECONDARY STANDARD–D: EARTH AND SPACE SCIENCE

1. Energy in the Earth System

a. Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the earth's original formation.

c. Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

d. Global climate is determined by energy transfer from the sun at and near the earth's surface.

SECONDARY STANDARD–E: SCIENCE AND TECHNOLOGY

1. Abilities of Technological Design

a. Identify a problem or design an opportunity.

b. Propose designs and choose between alternative solutions.

c. Implement a proposed solution.

d. Evaluate the solution and its consequences.

e. Communicate the problem, process, and solution.

SECONDARY STANDARD–F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

3. Natural Resources

a. Human populations use resources in the environment to maintain and improve their existence.

b. The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and depletes those resources that cannot be renewed.

c. Humans use many natural systems as resources. Natural systems have the capacity to reuse waste but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

4. Environmental Quality

a. Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.

b. Materials from human societies affect both physical and chemical cycles of the earth.

c. Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth.

5. Natural and Human-induced Hazards

d. Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards—ranging from those with minor risk to a few people to major catastrophes with major risk to many people.

6. Science and Technology in Local, National, and Global Challenges

a. Science and technology can indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.

b. Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology related challenges. However, understanding science alone will not resolve local, national, and global challenges.

c. Individuals and society must decide on proposals involving new research and the introduction of new technologies into society.

Teacher Guide

BACKGROUND

Exploring Hydroelectricity is a kit-based unit for secondary students that includes teacher and student guides containing comprehensive background information on hydropower, ocean energy technologies and electricity, with case studies, a history of hydropower timeline, and information on careers in the hydropower industry. The curriculum includes hands-on, inquiry-based explorations, group presentations, and a cooperative learning activity focusing on ways to use hydropower to increase electricity generation for a local community. The kit contains most of the materials to conduct the inquiry based activities.

Several activities in the unit are multidisciplinary and are appropriate for language arts and social studies classes.

GRADE LEVEL

Secondary—Grades 9-12

TIME

7–14 class periods depending on the length of class periods and the activities you choose to conduct.

CONCEPTS

- Energy is found in many forms—potential and kinetic.
- Many energy sources are converted into electricity because it is easy to transport and use.
- Moving water is a renewable energy source.
- People have used dams to control the water in rivers and extract its energy for many years.
- The energy of moving water can be harnessed and converted into electricity in many ways, including new technologies for harnessing the energy in ocean tides, waves, and currents.
- Hydropower has advantages and disadvantages.

PREPARATION

1. Read the **Teacher** and **Student Guides** thoroughly and decide how you are going to implement the unit in your classroom.
2. Obtain the additional materials needed for the hands-on activities (those marked with asterisks).
3. Assemble the **Science of Electricity Model** (pages 16-20) and become familiar with the operation of the model and the other equipment in the kit, especially the multimeter.
4. Assign students to groups and topics for the **Activity 1** presentation and **Hot Topics** activity.
5. Make copies of the **Hydropower Survey** (page 26) and relevant pages in the **Student Guide** so students do not write in the guides. It is suggested that students use science notebooks during the unit.

INTRODUCTION TO THE UNIT

MATERIALS: Science of Electricity Model, 1 multimeter, 1 set of alligator clips, water source*

1. Have the students take the **Hydropower Survey** on page 26 as a pre-test.
2. Have the students make **KWL Charts** in their science notebooks and individually list what they know and would like to know about hydropower and electricity, then have each student exchange his/her information with a classmate.
3. Facilitate a class discussion about the role of electricity in modern society and the importance of hydropower in generating electricity. This is not the time to correct misconceptions, but make note of them.

4. Demonstrate the operation of the **Science of Electricity Model** to stimulate interest in the topic. You can use the water reservoir unit or hold it under running water in a sink, with the wires ends connected to a multimeter to show that electricity is being generated. Do not go into details about its construction or operation at this time; allow the students in the **Electricity and Electromagnetism** group in **Activity 1** to explain the model during their presentation.
5. Assign students to presentation groups for **Activity 1** and give them instructions and a timeline for completing the assignment.

ACTIVITY 1––THE BASICS OF ENERGY, ELECTRICITY, AND WATER

1. Divide the students into six groups as follows:

   Forms of Energy *(Forms & Sources of Energy—page 30 of Student Guide)*
   Sources of Energy *(U.S. Energy Flow 2008—page 31 of Student Guide)*
   Atomic Structure
   Electricity and Electromagnetism *(U.S. Electricity Flow 2008—page 32 of Student Guide)*
   Measuring Electricity *(Measuring Electricity—pages 33–34 of Student Guide)*
   Characteristics of Water and The Water Cycle

2. Assign the groups to create five minute presentations to teach the other students the basics of their topics, using the information on pages 3–9 of the **Student Guide** and the worksheets as indicated above in parentheses. It is suggested that the students use one–two class periods to create their presentations.
3. Instruct the groups to use the **Presentation Topic Organizer** on page 29 of the **Student Guide** to plan their presentations. If desired, approve the groups' design plans before they proceed. Choose a specific format for the presentations—such as PowerPoints or tri-fold boards—or allow the groups to choose.
4. As the groups deliver their presentations, make sure the other students are taking notes and adding information to their **KWL Charts**.
5. Use the **Group Presentation Rubric** on page 11 to evaluate the presentations.
6. Have the students complete the **Science of Electricity Demonstration** worksheet on page 35 of the **Student Guide** as an assessment of understanding.

ACTIVITY 2––HISTORY & FUTURE OF HYDROPOWER

1. Have the students read about the history of hydropower on pages 10-11 and 25 of the **Student Guide**, and then the future of hydropower on pages 18-24 of the **Student Guide**. Instruct them to add new information to their **KWL Charts**.
2. Assign the students to write entries to add to the timeline for 2010, 2020, 2030, 2040, and 2050, detailing what they think the most important advances in hydropower will be.
3. Have the students share their ideas and discuss the future of hydropower in the U.S. and the world.

ACTIVITY 3––DAMS AND THEIR USES

1. Have the students read about dams on pages 12-15 of the **Student Guide**. Instruct them to add new information to their **KWL Charts**.
2. Assign the students to research the dams in their state or region and choose one on which to focus. Each student should write a short research paper on the dam he/she chooses, including the following information:
   - the location of the dam;
   - when the dam was built;
   - who built the dam;
   - why the dam was built;
   - the kind of dam it is;
   - the benefits of the dam; and
   - the environmental impacts of the dam.
3. Have the students share what they have learned about the dams with the class.

ACTIVITY 4––TURBINE ASSEMBLY & EXPLORATIONS

Materials at each of three testing centers: 1 water reservoir unit filled (with water), 1 set of alligator clips, 1 voltmeter/multimeter, 1 funnel

Materials at each of six centers: 1 rectangular jug, 4 1-hole stoppers, 4 circular magnets, 1 4-cm foam hub, 8 wooden blades, 1 1-cm piece of plastic tubing, 1 spool of coated magnet wire, 1 roll of double-sided tape, 1 wood dowel, 1 cardboard tube for a form, 2 compact discs*, 1 sharp-pointed scissors*, 1 fine point permanent marker*, 1 roll of masking tape*, 1 small piece of fine sandpaper*, 1 nail*, 1 bottle of fast-drying glue*, 1 meter stick*, 1 5-gallon water collection bucket*, water supply*, 1 pushpin*

***Not included in kit**

Preparation

1. Gather the materials not included in the kit—those materials marked with asterisks. (The compact discs can be old or unreadable.)
2. Cut the plastic tubing into 6 1-cm lengths.
3. Cut the foam tubes into 4-cm lengths. You will need to cut enough hubs for six groups of students in every class.
4. You will need six sets of 8 wooden blades for every class.
5. Develop a class schedule for completing the explorations—each exploration will take approximately 20-30 minutes. In addition, it will take 20-30 minutes to assemble the turbine for the first time and 5-10 minutes each time thereafter, 5 minutes to become familiar with the water reservoir unit on the first day, and 5-10 minutes to disassemble the turbine.

Materials Management Tips

1. If you are using the materials with multiple classes only the first class of students will be responsible for cutting the bottoms off the jugs and making the holes for the dowels. ***If desired, the teacher can cut the bottoms off the jugs and make the holes for the dowels so that there is uniformity among the materials across the classes.***
2. The explorations will probably take more than one class period, so you need to schedule time for each class of students to disassemble the turbines, including removing the double-sided tape from the jugs, CDs and magnets. Each group of students should also empty the water from their water reservoir units and water collection buckets and return it to the water reservoir unit.
3. One new hub, 1 CD, and 8 wooden blades must be added to each center for every additional class. Each group of students in each class will build its own hub and CD with wire coils—and use these for all of the explorations. They will need to mark their hubs and CDs and store them between classes. Each group must reassemble the turbine each day that they conduct the explorations.

Procedure

1. Review the **Turbine Component Assembly Instructions**, **Turbine Unit Assembly Instructions**, **Turbine Unit Templates**, and **Water Reservoir Unit Instructions** with the students (pages 36-39 of the **Student Guide**). Also review the Hints, Tips, and Cautions on page 20 of the Teacher's Guide.
2. Explain the schedule for the explorations.
3. Explain that each group of students must mark and keep its own hub and CD with wire coils throughout the explorations.
4. Review the explorations with the students (pages 40-42 of the **Student Guide**). Answer any questions. Instruct the students to formulate hypotheses to answer the questions in the explorations, using their science notebooks.
5. Review the operation of the multimeter with the students (see page 16), including how to attach the multimeter to the turbine with the alligator clips.
6. Instruct the students to complete the explorations, being mindful of time management in regard to the disassembly of the turbines in preparation for the next class.
7. Use the **Turbine Assessment** on page 43 of the **Student Guide** to evaluate student understanding. Correct any misconceptions at this time.
8. Use the **Inquiry Explorations Rubric** to evaluate student performance.

ACTIVITY 5––ADVANTAGES & DISADVANTAGES OF CONVENTIONAL HYDROPOWER

1. Have the students read about the advantages and disadvantages of hydropower on page 16 of the **Student Guide**. Instruct them to add new information to their **KWL Charts**.
2. Have the students write persuasive essays on whether they think the advantages of hydropower outweigh the disadvantages, or vice versa.
3. Facilitate a class discussion of the advantages and disadvantages of hydropower to generate electricity.

ACTIVITY 6––NEW TECHNOLOGIES IN OCEAN ENERGY

1. Have the students review the information on ocean energy technologies on pages 20-24 of the **Student Guide**.
2. Assign the students to research one of the technologies and write a one-page paper on the future of the technology, including:
    - ♦ the future potential of the technology;
    - ♦ the advantages of the technology;
    - ♦ where the technology could be utilized; and
    - ♦ examples of the technology in use today.
3. Have the students share what they have learned with the class.

ACTIVITY 7––CAREERS IN THE HYDROPOWER INDUSTRY

1. Have the students read through the list of careers in the hydropower industry on pages 26-27 of the **Student Guide**.
2. Instruct each student to choose a career that sounds interesting to him/her and conduct research on that career using the resources on page 28.
3. Have each student write a resume to be used to apply for a job in the career he/she has researched, including:
    - ♦ the education he/she has completed to prepare for the job;
    - ♦ other training he/she has had;
    - ♦ internships or other experiences that make him/her a good candidate for the job;
    - ♦ personal characteristics and skills he/she has that are necessary to be successful in the job; and
    - ♦ personal interests that make him/her a good candidate for the job.

CULMINATING ACTIVITY––HOT TOPICS IN HYDROPOWER

1. Choose one of the scenarios for the activity found on pages 24 and 25 in the Teacher Guide.
2. Divide the students into role groups—**Scenario 1** has 14 roles, **Scenario 2** has 16. Assign each group to one of the specific roles.
3. Explain the activity to the students. Have the students read the description of the activity and review the scenario. Discuss.
4. Guide the students to the **Issue Organizer** on page 44 of the **Student Guide**. Explain that each student should complete the organizer individually, then meet in groups to organize and present the information they have gathered.
5. Instruct the students to use the background material on pages 10-24 in the **Student Guide**, as well as outside research, to complete the organizer.
6. After the students have completed the organizers individually, have them meet in their role groups to discuss their findings. Instruct the students to add to their organizers any additional information provided by group members.

7. After the students have met in the role groups and completed their discussions, have each group develop a presentation to be made to the council. Each group must choose a spokesperson to represent it at the meeting to make the presentation.
8. Give the groups a timeframe in which to complete their presentations. Two class periods are recommended.
9. Conduct the council meeting and have the class decide on the actions that should be taken. Discuss.

EVALUATION

1. Use the **Inquiry Explorations, Presentation** and **Culminating Projects Rubrics** on pages 10-11 to evaluate student performance.
2. Have the students take the **Hydropower Survey** on page 26 as a post-unit evaluation.
3. Evaluate the unit with the students using the **Evaluation Form** on page 27 and return to NEED.

Hydropower Survey Answer Key

1. a 2. b 3. c 4. a 5. d 6. c 7. d 8. d 9. d 10. b

GRADING RUBRIC––INQUIRY EXPLORATIONS

Grade	Scientific Concepts	Diagrams	Procedures	Conclusions
4	Written explanations illustrate accurate and thorough understanding of scientific concepts underlying inquiry.	Comprehensive diagrams are accurately and neatly labeled and make the designs easier to understand.	Procedures are listed in clear steps. Each step is numbered and is written as a complete sentence.	Conclusions describe information and skills learned, as well as some future applications to real life situations.
3	Written explanations illustrate an accurate understanding of most scientific concepts underlying inquiry.	Necessary diagrams are accurately and neatly labeled.	Procedures are listed in a logical order, but steps are not numbered or are not in complete sentences.	Conclusions describe the information learned and a possible application to a real life application.
2	Written explanations illustrate a limited understanding of scientific concepts underlying inquiry.	Necessary diagrams are labeled.	Procedures are listed but are not in a logical order or are difficult to understand.	Conclusions describe the information learned.
1	Written explanations illustrate an inaccurate understanding of scientific concepts.	Necessary diagrams or important components of diagrams are missing.	Procedures do not accurately reflect the steps of the design process.	Conclusions are missing or inaccurate.

Grading Rubric—Group Presentations

Grade	Content	Organization	Originality	Workload
4	Presentation covers the topic in-depth with many details and examples. Subject knowledge is excellent.	Content is very well organized and presented in a logical sequence.	Presentation shows much original thought. Ideas are creative and inventive.	The workload is divided and shared equally by all members of the group.
3	Presentation includes essential information about the topic. Subject knowledge is good.	Content is logically organized.	Presentation shows some original thought. Work shows new ideas and insights.	The workload is divided and shared fairly equally by all group members, but workloads may vary.
2	Presentation includes essential information about the topic, but there are 1-2 factual errors.	Content is logically organized with a few confusing sections.	Presentation provides essential information, but there is little evidence of original thinking.	The workload is divided, but one person in the group is viewed as not doing fair share of the work.
1	Presentation includes minimal information or there are several factual errors.	There is no clear organizational structure, just a compilation of facts.	Presentation provides some essential information, but no original thought.	The workload is not divided, or several members are not doing fair share of the work.

Grading Rubric—Culminating Projects

Grade	Content	Organization	Originality	Workload
4	Project covers the topic in-depth with many details and examples. Subject knowledge is excellent.	Content is very well organized and presented in a logical sequence.	Project shows much original thought. Ideas are creative and inventive.	The workload is divided and shared equally by all members of the group.
3	Project includes essential information about the topic. Subject knowledge is good.	Content is logically organized.	Project shows some original thought. Work shows new ideas and insights.	The workload is divided and shared fairly equally by all group members, but workloads may vary.
2	Project includes essential information about the topic, but there are 1-2 factual errors.	Content is logically organized with a few confusing sections.	Project provides essential information, but there is little evidence of original thinking.	The workload is divided, but one person in the group is viewed as not doing fair share of the work.
1	Project includes minimal information or there are several factual errors.	There is no clear organizational structure, just a compilation of facts.	Project provides some essential information, but no original thought.	The workload is not divided, or several members are not doing fair share of the work.

ENERGY MEASUREMENTS

1 cal	=	Calorie—a measure of heat energy—the amount of heat energy needed to raise the temperature of one gram of water by one degree Celsius.
1 cal	=	4.187 joules
1 Btu	=	British thermal unit—a measure of heat energy—the amount of heat energy needed to raise the temperature of one pound of water by one degree Fahrenheit. One Btu is approximately the amount of energy released by the burning of one wooden kitchen match.
1 Btu	=	1,054 joules
1 Btu	=	252 calories
1 Q	=	Quad—1 quadrillion Btu. Quads are used to measure very large quantities of energy. The U.S. uses one quad of energy about every 3.7 days.
1 therm	=	100,000 Btu; approximately the amount of heat energy in one CCF of natural gas.
1 kWh	=	Kilowatt-hour—one kilowatt of electricity over one hour. One kilowatt-hour of electricity is the amount of energy it takes to burn a 100 watt light bulb for 10 hours. The average cost of one kilowatt-hour of electricity for residential customers in the U.S. is about nine cents.
1 kWh	=	3.6 million joules (3.6 Mj).
1 kWh	=	3,412 Btu
1 CF	=	Cubic foot—a measure of volume—one CF of natural gas contains about 1,020 Btu.
1 CCF	=	One hundred cubic feet—one CCF of natural gas contains about one therm of heat energy.
1 MCF	=	One thousand cubic feet—one MCF of natural gas costs $5–$10.

ENERGY FLOW DIAGRAM EXPLANATION

The left side of the diagram shows energy production (supply) figures for 2006 in the U.S. by source and imports:

The top four on the list—coal, natural gas, crude oil, and NGPL—are fossil fuels that provided 56.03 quads of energy.

Uranium (nuclear) produced 8.21 quads of energy.

Renewables (solar, wind, hydropower, geothermal, and biomass) produced 6.79 quads of energy.

The bottom two show imports—mostly crude oil and petroleum products that produced 27.68 quads of energy, while all other imported energy produced 5.33 quads of energy.

The adjustment figure is a ‘balancing’ figure so that both sides of the graph are equal and includes uncounted inputs.

The diagram shows that most of 2006 U.S. energy supply came from fossil fuels and that the U.S. imported 32.91% of its total energy supply.

The right side of the diagram shows energy consumption figures by energy source and sector of the economy:

The U.S. exported 4.93 quads of energy in 2006.

The residential sector (homes) consumed 21.05 quads of energy or 21.08% of total energy consumption.

The commercial sector (businesses) consumed 18.0 quads of energy or 18.02% of total energy consumption.

The industrial sector (manufacturing) consumed 32.43 quads of energy or 32.47% of total energy consumption.

The transportation sector (vehicles) consumed 28.4 quads of energy or 28.43% of total energy consumption.

ELECTRICITY FLOW DIAGRAM EXPLANATION

The left side of the diagram shows energy sources used to generate electricity in 2006 in the U.S.:

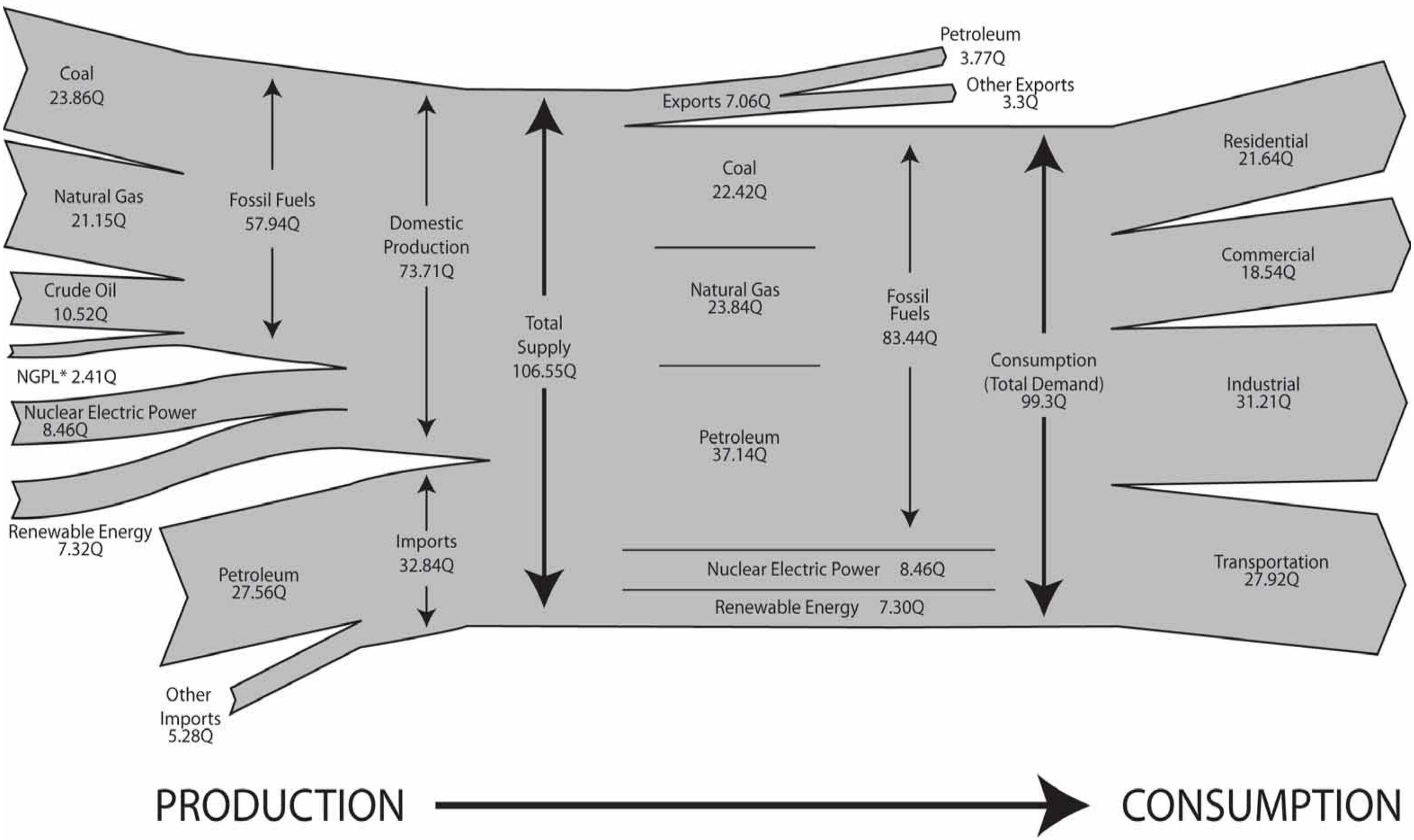
Coal produced 49.35 percent of electricity in the U.S., followed by uranium and natural gas. Renewables are used to generate a little over 10 percent of U.S. electricity.

The right side of the diagram shows electricity consumption figures by sector of the economy:

Notice that only 13.03 Q of electricity (31 percent of total generation) are actually used by consumers—the other 69 percent is lost during conversion and distribution—or used by the power plant in operation.

U.S. Energy Flow 2008

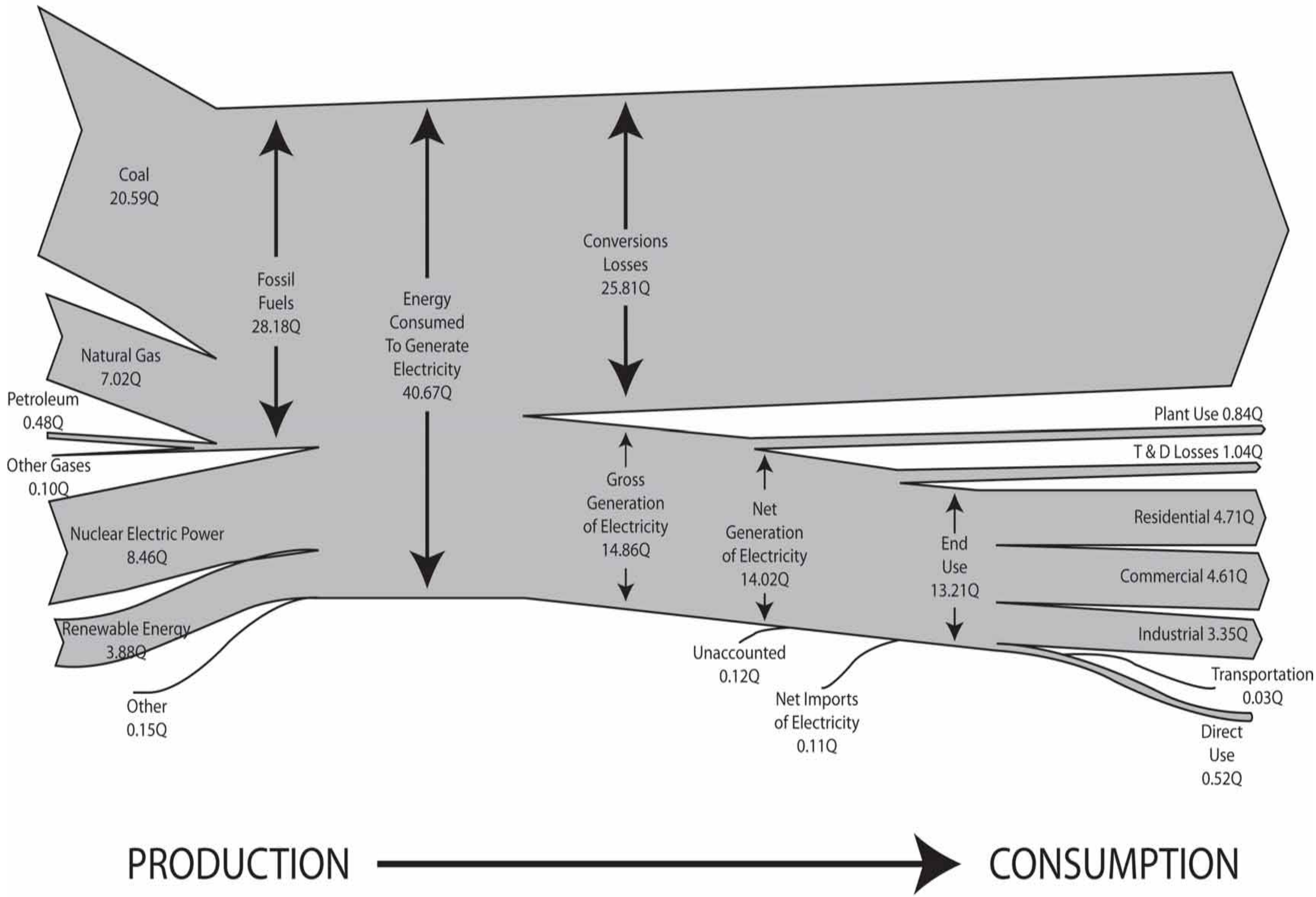
(Quadrillion Btu)



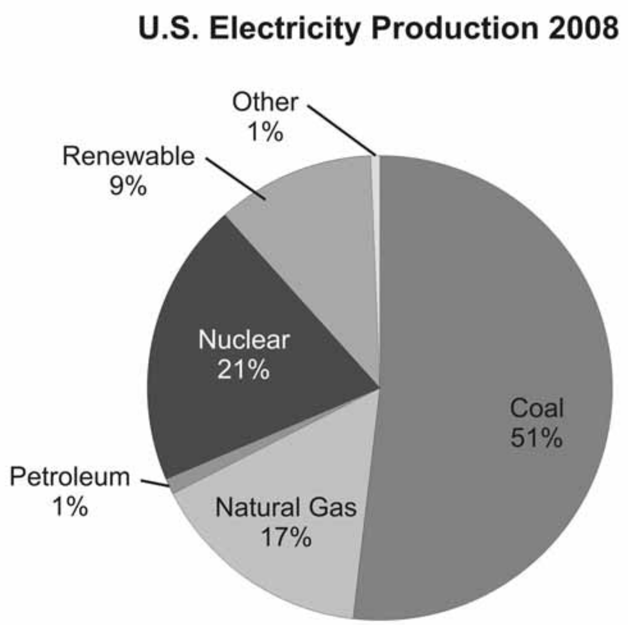
*NGPL (Natural Gas Plant Liquids) include petroleum and propane.

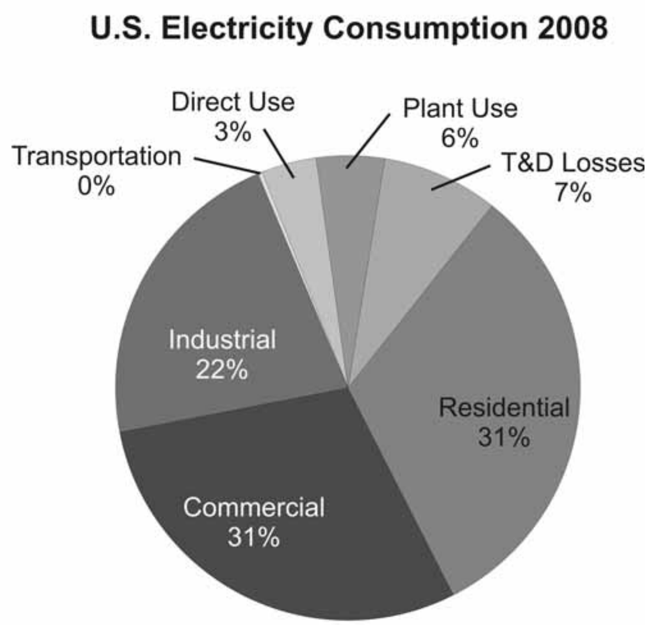
U.S. ELECTRICITY FLOW 2008

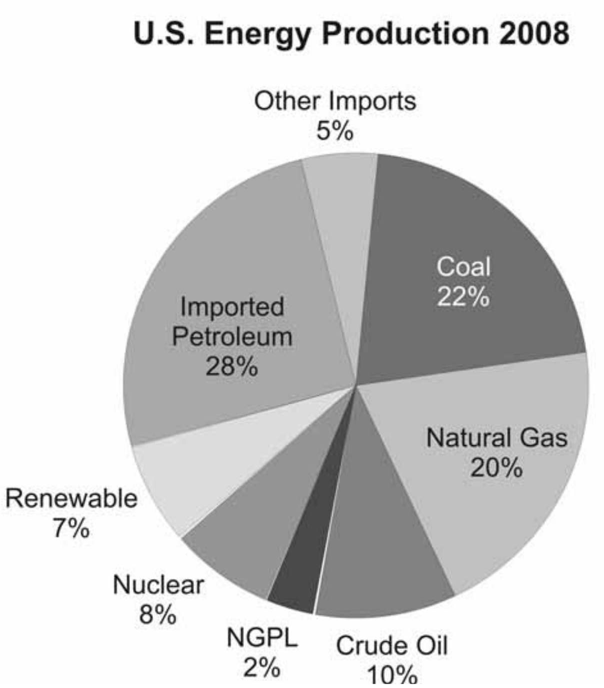
(Quadrillion Btu)

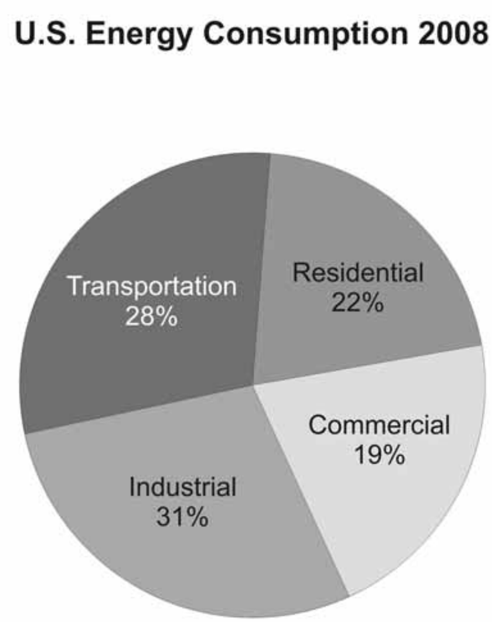


Energy and Electricity Flow Graphing Answer Keys

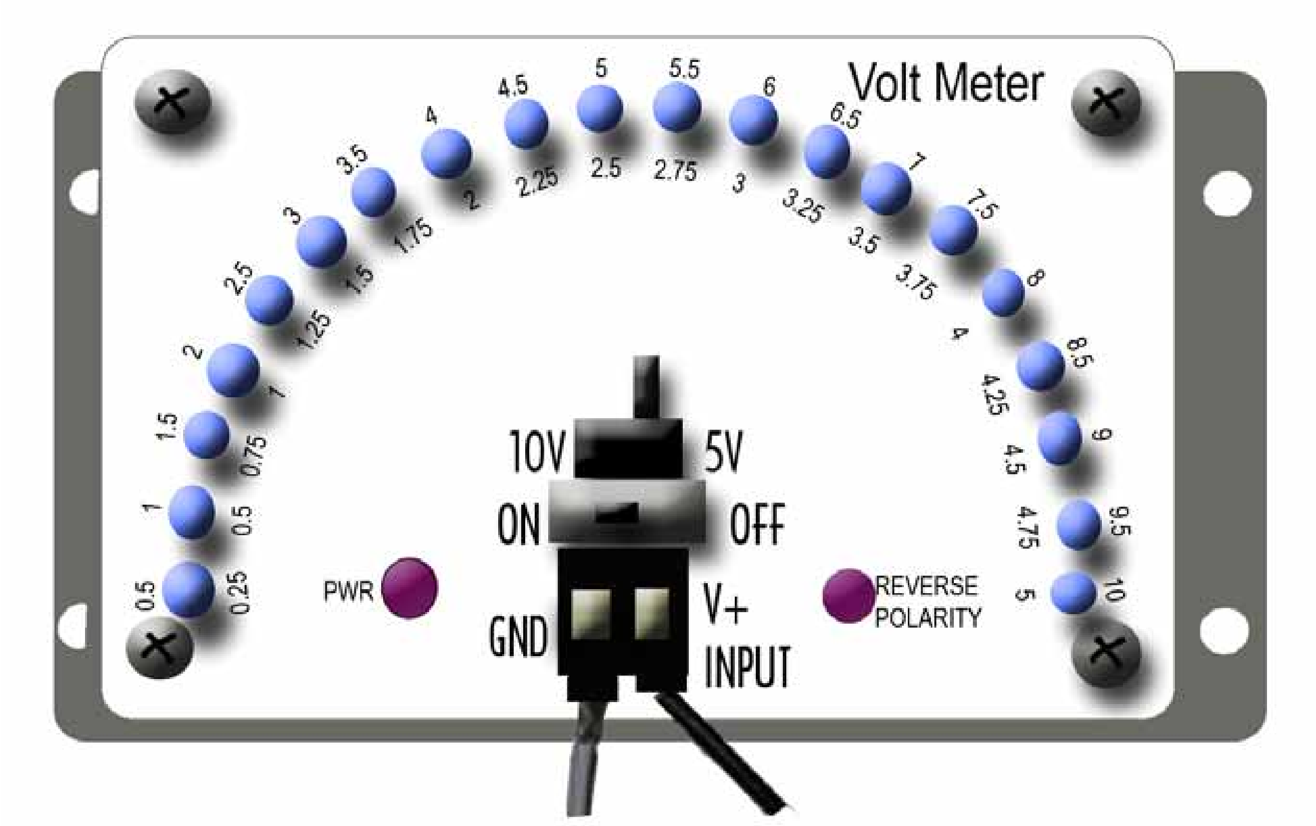








VOLTMETER DIRECTIONS



Directions:

1. Switch the tab over to 5V.

2. Press down on the "GND" button. Insert one end of the copper wire into the hole on the bottom. Release the button to secure the wire in place.

3. Repeat step two with the other wire on the "V+ Input" side.

4. Turn the volt meter on.

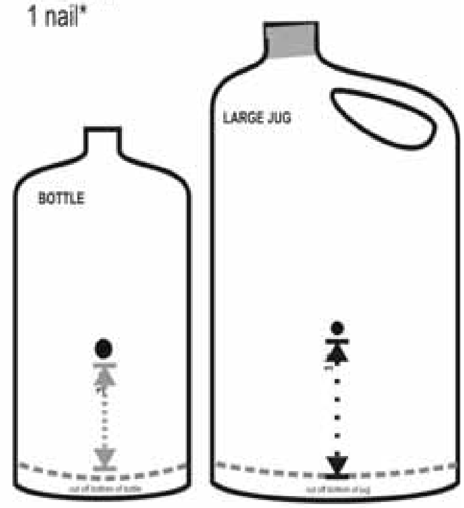
5. Place the Science of Electricity hub under water. The lights on the volt meter will light indicating how much electricity is being generated.

*If the "Reverse Polarity" light flashes switch the wires in the "GND" and "V+ Input" locations.

SCIENCE OF ELECTRICITY MODEL

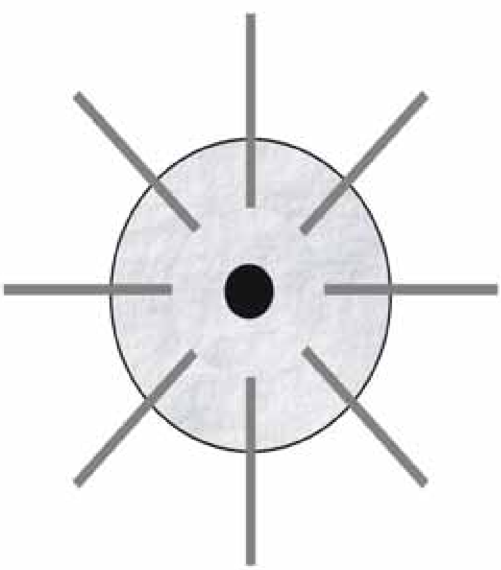
Materials *(the materials marked with asterisks are not in the kit)*:

1 large plastic jug with handle
1 piece foam tube (4 cm width)
5 rubber stoppers with 1/4" hole
tape*
marker*
1 small plastic bottle
8 wooden blades
1 glue*
1 fine sandpaper*
1 wooden dowel (12" x 1/4")
4 strong rectangle magnets
Magnet Wire
1 sharp-pointed scissors*
1 nail*



Preparing the Jug and Bottle

1. Cut the bottom off the jug and the bottle as evenly as possible.
2. Measure 3 inches up from the bottom. (You may use the spool of wire standing endwise as a quick gauge of measurement.) Mark this location with a permanent marker. HINT: If the jug you're using has visible seams, measure along these lines so your holes will be on the opposite sides of the bottle.
3. On the exact opposite side of the jug, measure 3 inches up and mark this location with a permanent marker.
4. Over each mark, poke a hole with a push pin. Do not distort the shape of the bottle as you do this. Hold one of the rubber stoppers inside the jug behind where the hole will be so the push pin will hit the rubber stopper once it pokes through the jug.
5. Widen each hole by pushing a nail through. Continue making the hole bigger by circling the edge of the hole with the side of the nail. (A 9/32 drill bit twisted slowly also works using a rubber stopper on the end of the bit as a handle.)
6. Use a round barreled ink pen to push through the hole. Circle the edge of the hole with the pen so that the hole is a little bigger than the dowel.
7. Take the large jug and slide the dowel through. Take each end of the dowel and swing the jug around the dowel. You should have a good, smooth rotation. Test the holes in the bottle following the same steps.



Hub Assembly

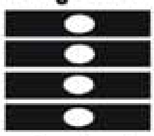
1. Measure 4cm from the end of the foam tube. Using scissors, carefully score a circle around the tube. Snap the piece from the tube. This is your hub.
2. Insert a small nail straight directly through the hub's center.
3. Remove the small nail and insert a bigger nail.
4. Remove the nail and push the dowel through.
5. Push your blades into the hub so they are evenly spaced. Reinforce the blades with a little bit of glue.
6. Remove the dowel and let the hub dry.

Magnet Assembly (Rotor)

Follow the separate Magnet Assembly directions on the following page.

SCIENCE OF ELECTRICITY MAGNET ASSEMBLY (ROTOR)

Diagram 1



Stacked Magnets End View

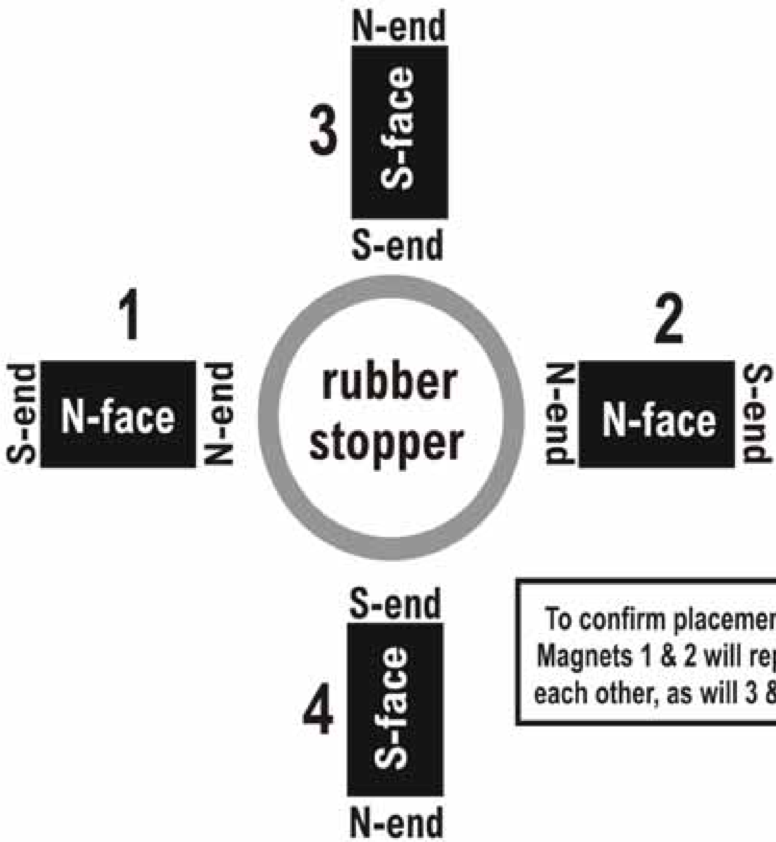
1. While stacked, mark one end (it doesn't matter which end) of each of the stacked magnets with a permanent marker to indicate the N-end as shown in Diagram 1.

Diagram 2

Stacked Magnets Top View

2. Mark the top face of each stacked magnet with an N using a permanent marker in turn as you remove the magnets from the top one at a time and place around the stopper in the configuration below left. Make sure you place the magnets at a distance so they don't snap back together. The unmarked faces and ends of the magnets will indicate the S poles.

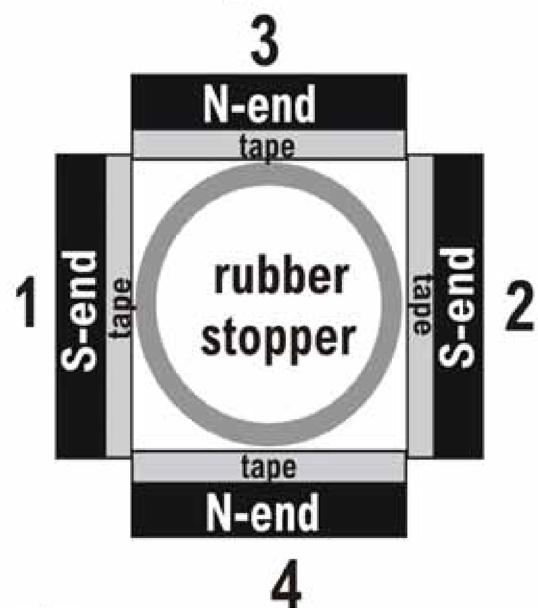
Diagram 3



To confirm placement, Magnets 1 & 2 will repel each other, as will 3 & 4.

OVERHEAD VIEWS OF MAGNET ASSEMBLY

Diagram 4

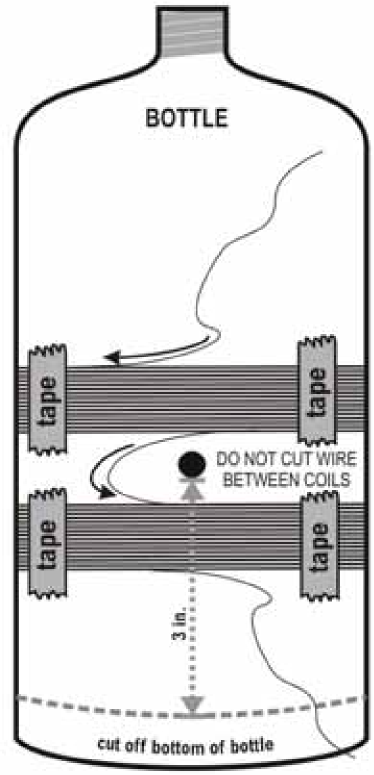


3. Wrap a piece of masking tape around the rubber stopper, sticky side out.
4. Lift the S-end of Magnet 1 to a vertical position and stick it to the stopper.
5. Attach Magnet 2, then 3, then 4 to the stopper one at a time following the same procedure.
6. Secure the magnets in place by wrapping another piece of masking tape over the magnets, sticky side down. Fold the tape edges onto the stopper, but do not cover the hole in the middle of the stopper.

SCIENCE OF ELECTRICITY MODEL ASSEMBLY

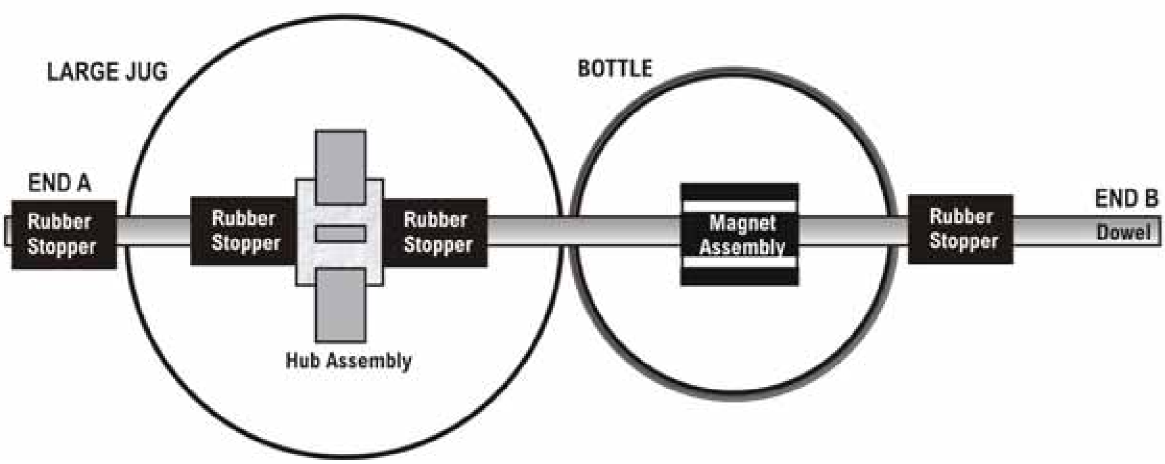
Generator Assembly

1. Take the bottle and the magnet wire. Leave a 4 inch tail, and tape the wire to the bottle at the 4 inch mark about ½ inch below one of the holes. Wrap the wire clockwise 100 times, stacking the wire on top of each other. Keep the wire wrap below the holes, do not cover the holes.
2. DO NOT cut the wire.
3. Use two pieces of tape to hold the coil of wire in place, do not cover the holes with the tape.
4. Without cutting the wire, move the wire above the hole to begin the second coil of wraps.
5. Wrap the wire 100 times counter clockwise, again stacking the wire as you wrap.
6. Hold the coil in place with two pieces of tape.
7. Unwind 4 inches of wire (for a tail) from the spool and cut the wire.
8. Check your coil wraps. Using your fingers, pinch the individual wire wraps to make sure the wire is close together. Re-tape the coils in place as needed.
9. Using fine sandpaper, remove the enamel coating from 1 inch of the end of each wire tail.



Model Assembly

1. Using a pencil, mark one end of the dowel with the letter “A” and the other end with the letter “B.”
2. Slide End A of the rod through one hole of the jug.
3. Inside the jug, put on a stopper, the hub, and another stopper. The stoppers should hold the hub in place. If the hub spins freely on the axis push the two stoppers closer against the hub. This is a pressure fit and no glue is needed.
4. Slide End A through the other side of the jug so that End A sticks out about one inch outside of the jug.
5. Place a rubber stopper onto End A. Adjust the hub and stoppers as needed.
6. Slide the bottle onto End B. Make sure that the wire ends are facing away from the jug.
7. Inside of the bottle, slide the rotor onto the dowel then slide End B through the other side of the bottle.
8. Move the bottle along the dowel until the bottle is next to the jug. Adjust the rotor so that it is in the middle of the bottle.
9. Slide a rubber stopper onto End B of the dowel so it is close to, but not touching the bottle.
10. Make sure your dowel can spin freely. Adjust components as needed.
11. You are ready to test your generator.



Hints, Tips, and Cautions for Hydropower Turbine Models

<u>Magnets</u>

1. The magnets are very strong. In order to separate them students should slide/twist them apart.

2. When students set the magnets down they should place them far enough away from each other that the magnets won't snap back together.

3. The tape should hold the magnets on. If you want something stronger and more permanent you can use hot glue.

4. When you are finished with the magnets and ready to store them put a small piece of cardboard between them.

5. Keep magnets away from your computer screen, cell phone, debit/credit cards, and ID badges.

<u>Turbines</u>

If the voltmeter is not picking up a reading check the following:

1. Was the wire coating removed from the ends of the ends of the wire?

2. Were the the coils of wire placed on the template as directed, rotating clock wise and counter-clockwise?

3. Are the magnets alternating north and south facing?

WATER RESERVOIR UNIT INSTRUCTIONS

1. Examine the water reservoir unit. Become familiar with the operation of the hose clamp.
2. To fill the unit with water, place the unit with the opening on top and the spout lifted. Fill the unit completely with water. Tighten the top securely and make sure the clamp on the hose is shut.
3. Lift the hose above the unit, slightly open the clamp and put pressure on the unit to remove any air pockets at the top of the unit. Close the clamp.
4. Place the unit on its side with the spout near the bottom when conducting all experiments, as shown in Diagram 1. Make sure there are no air pockets in the unit when you place it on its side to conduct the experiments.
5. Make sure that there are no kinks in the hose when conducting experiments.
6. When conducting the experiments, pinch the hose closed and remove the clamp to ensure a constant rate of flow. Replace the clamp and close it to refill the unit.
7. Make sure the water from the hose hits the blades of the hub as shown in Diagram 2.
8. After each trial, use the funnel to pour the water from the bucket back into the unit. If necessary, add more water so that the unit is completely full.

Diagram 1

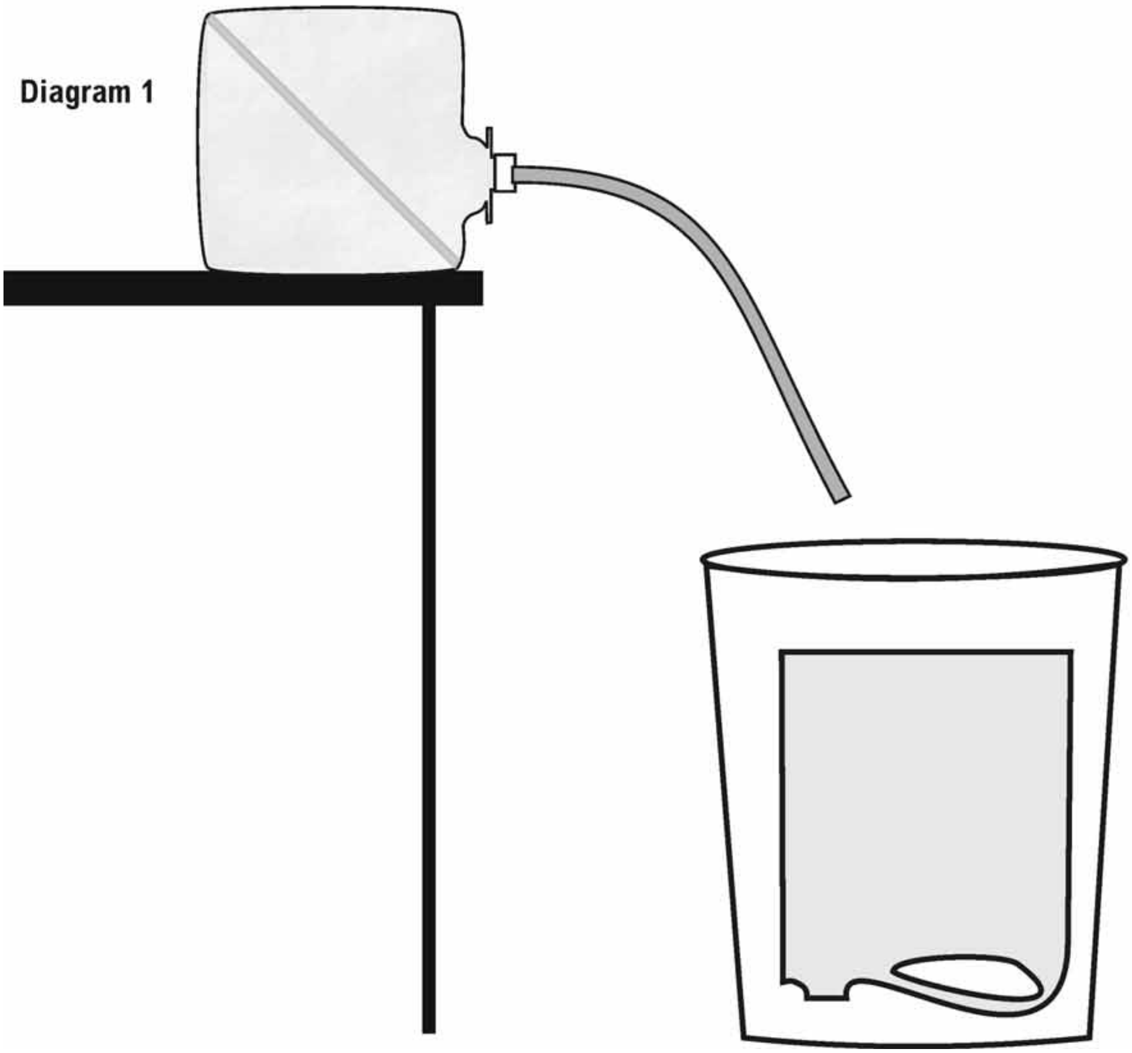
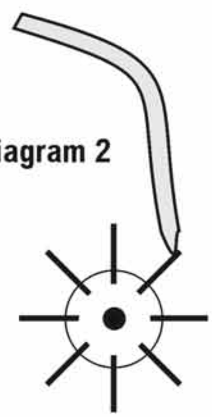


Diagram 2



FORMS & SOURCES OF ENERGY

1. Write the form in which the energy is stored or delivered for each source on the line to the right of the source.

RENEWABLE		NONRENEWABLE	
Biomass	CHEMICAL	Petroleum	CHEMICAL
Hydropower	MOTION	Natural Gas	CHEMICAL
Geothermal	THERMAL	Coal	CHEMICAL
Wind	MOTION	Uranium	NUCLEAR
Solar	RADIANT	Propane	CHEMICAL

2. What percentage of the nation's energy is provided by each form of energy? By renewables? By nonrenewables?

Chemical	88.2%	Renewables	6.9%
Nuclear	8.2%	Nonrenewables	93.1%
Motion	3.15%		
Thermal	0.35%		
Radiant	0.1%		

U.S. Energy Consumption by Source 2006

PETROLEUM 38.8% nonrenewable transportation, manufacturing		**BIOMASS** 3.3% renewable heating, electricity, transportation	
COAL 22.6% nonrenewable electricity, manufacturing		**HYDROPOWER** 2.9% renewable electricity	
NATURAL GAS 21.6% nonrenewable heating, manufacturing, electricity		**GEOTHERMAL** 0.35% renewable heating, electricity	
URANIUM 8.2% nonrenewable electricity		**WIND** 0.25% renewable electricity	
PROPANE 1.9% nonrenewable manufacturing, heating		**SOLAR** 0.1% renewable light, heating, electricity	

Electricity Calculations Answer Key

Table 1

Voltage	=	Current	x	Resistance
1.5 V	=	0.5 A	x	3 Ω
12 V	=	3 A	x	4 Ω
120 V	=	4 A	x	30 Ω
240 V	=	120 A	x	12 Ω

Table 2

Power	=	Voltage	x	Current
27 W	=	9 V	x	3 A
180 W	=	120 V	x	1.5 A
45 W	=	15 V	x	3 A
240 W	=	120 V	x	2 A

Table 3

Appliance	Power	=	Voltage	x	Current
TV	180 W	=	120 V	x	1.5 A
Computer	40 W	=	120 V	x	0.33 A
Printer	120 W	=	120 V	x	1 A
Hair Dryer	1,000 W	=	120 V	x	8.33 A

Table 4

POWER	x	TIME	=	ELECTRICAL ENERGY	x	PRICE	=	COST
5 kW	x	100 h	=	500 kWh	x	$0.09	=	$45.00
1000 W	x	1 h	=	1000 Wh = 1 kWh	x	$0.09	=	$0.09
25 kW	x	4 h	=	100 kWh	x	$0.09	=	$9.00

HOT TOPICS IN HYDROPOWER

You have been assigned to represent a stakeholder in one of the scenarios below. Your assignment is to research and write a persuasive essay supporting your position. You will also make a presentation to the City or Town Council and be expected to defend your position. Use the Issue Organizer on page 36 to organize the information for your presentation.

SCENARIO 1

You reside in a growing coastal town on the ocean. Most of the town's income is from commercial fishermen, sports fishermen, and summer vacationers. A manufacturing company has expressed interest in building a new plant near your town that would offer employment opportunities to local residents. Your electricity is supplied by a municipal hydropower plant, but it cannot produce the electricity the plant needs to operate. Several proposals have been made to generate more electricity by building a tidal or wave plant, or by increasing the electricity produced by the hydropower plant. Give at least three reasons for your position, and support each reason with three facts.

- Municipal Power Plant Manager: Wants to improve the current dam facility, upgrading it to produce more electricity.
- Resident: Wants economical electricity and also new job opportunities.
- Ocean View Homeowners Association: Wants to protect views and property values.
- Local Indian Tribe: Wants to protect its fishing rights in the ocean.
- Sports Fisherman's Association: Wants to protect fish population.
- Commercial Fisherman's Union: Wants to protect fish population.
- Mayor: Wants to improve town's business options.
- Marine Biologist: Wants to protect the local marine environment.
- Environmentalist: Wants the dam torn down so the river can return to its original state.
- Marine Mammal Activist: Wants to ensure marine life is protected.
- Renewable Energy Enthusiast: Wants to encourage the expansion of renewable energy technologies.
- Hydro Developer: Wants to bring new hydropower technologies to area as demonstration projects.
- Plant Manufacturer: Wants to build a new manufacturing plant near the town and needs a reliable supply of electricity.
- Elderly Resident on Fixed Income: Wants to make sure electricity rates don't increase.

SCENARIO 2

You live in a city where historically there was a large salmon population in the local river. The river was dammed 100 years ago by the local energy company to produce electricity for the city and surrounding area. No fish ladders were built around the dam. Now many people want to decommission the dam to restore the river and allow salmon to return to their native habitat. This would mean developing a new source for electricity. Based on your assigned role, research the effects of maintaining the dam as it is, upgrading the dam with fish ladders and more efficient turbines, and dismantling the dam. Give at least three reasons for your position, and support each reason with three facts. (Research Elwha River Dam: www.nps.gov/olym/naturescience/elwha-ecosystem-restoration.htm.)

- Local Energy Company: Wants to maintain the dam and provide economical electricity.
- Residential Consumer: Wants a reliable source of economical electricity.
- Local Indian Tribe: Wants to protect its fishing rights in the river and reservoir.
- Sports Fisherman: Wants fish population to remain high downstream from the dam.
- Mayor: Wants to protect city services, improve business opportunities, and maintain way of life.
- Environmental Biologist: Wants to protect the river environment.
- Environmental Activist: Wants the river returned to its natural state.
- Renewable Energy Enthusiast: Wants to make sure renewable energy is used to generate the city's electricity.
- River Property Owner: Wants to make sure his property is protected and property values maintained.
- Reservoir Property Owner: Wants to make sure his property is protected and property values maintained.
- Recreational Boater: Wants to be able to continue boating on the reservoir.
- Hydro Developer: Wants to install new hydropower technologies at existing dam.
- Wind Developer: Wants to build a wind farm on a nearby mountain to provide electricity.
- City Waste Treatment Facility: Wants to maintain its services without change. It is located right next to the river, and has been dumping treated sewage into the river. If the dam is decommissioned, it may have to relocate and change its practices.
- City Water Board: Wants to maintain reliable source of drinking water. The reservoir has been used to supply drinking water to the city.
- Elderly Resident on Fixed Income: Wants to make sure electricity rates don't increase.

HYDROPOWER SURVEY

1. The energy stored in the chemical bonds of fossil fuels and biomass is…
   a. potential   b. radiant   c. kinetic   d. electrical

2. Renewable energy sources provide what percentage of total U.S. energy consumption?
   a. 1%   b. 5-10%   c. 10-20%   d. 20-30%

3. The process that draws water from oceans into the atmosphere to form clouds is…
   a. sublimation   b. deposition   c. evaporation   d. precipitation

4. The energy of moving water is fueled by…
   a. gravitational force   b. radiant energy   c. the water cycle   d. precipitation

5. A dam on a river can provide…
   a. electricity   b. flood control   c. irrigation   d. all of these

6. Hydropower can provide…
   a. baseload power   b. peak demand power   c. both baseload and peak demand power

7. A device that captures the energy of moving water in a hydropower dam is called a…
   a. motor   b. generator   c. electrometer   d. turbine

8. A hydropower generator converts…
   a. potential energy to electrical energy
   b. kinetic energy to potential energy
   c. chemical energy to kinetic energy
   d. kinetic energy to electrical energy

9. Technologies are currently available to harness the energy of…
   a. ocean currents
   b. ocean tides
   c. ocean waves
   d. all of the above

10. Hydropower produces what percentage of total electricity generation in the U.S. today?
    a. 1-3%   b. 6-8%   c. 15-17%   d. 25-27%

EXPLORING HYDROELECTRICITY
Evaluation Form

State: ___________ Grade Level: ___________ Number of Students: __________

1.	Did you conduct all of the activities?	Yes	No
2.	Were the instructions clear and easy to follow?	Yes	No
3.	Did the activities meet your academic objectives?	Yes	No
4.	Were the activities age appropriate?	Yes	No
5.	Were the allotted times sufficient to conduct the activities?	Yes	No
6.	Were the materials easy to use?	Yes	No
7.	Was the preparation required acceptable for the activities?	Yes	No
8.	Were the students interested and motivated?	Yes	No
9.	Was the energy knowledge content age appropriate?	Yes	No
10.	Would you use the activities again?	Yes	No

How would you rate the activities overall (excellent, good, fair, poor)?

How would your students rate the activities overall (excellent, good, fair, poor)?

What would make the activities more useful to you?

Other Comments:

Please fax or mail to:

NEED Project
PO Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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